C 16

Proposed National Strategies for the Prevention of Leading Work – Related Diseases and Injuries

• Occupational Cancers •

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

HE 20.7102:

Proposed National Strategy for the Prevention of Occupational Cancers

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health
1986

DHHS(NIOSH)Publication No. 89-130

Introduction

This document, *A Proposed National Strategy for the Prevention of Occupational Cancers*, summarizes what actions need to be taken to prevent occupational cancers. It was developed in 1985 at a conference sponsored by the National Institute for Occupational Safety and Health (NIOSH) and The Association of Schools of Public Health (ASPH), which brought together over 50 expert panelists and 450 other occupational safety and health professionals.

In addition to the strategy for occupational cancers, NIOSH and ASPH have published strategies for the other nine leading occupational diseases and injuries: occupational lung diseases, musculoskeletal injuries, severe occupational traumatic injuries, occupational cardiovascular diseases, disorders of reproduction, neurotoxic disorders, noise-induced hearing loss, dermatological conditions and psychological disorders.

The proposed strategies were originally published in a two volume set, *Proposed National Strategies for the Prevention of Leading Work Related Diseases and Injuries, Part 1 and Part 2*. These proposed strategies are not to be considered as final statements of policy of NIOSH, The Association of Schools of Public Health, or of any agency or individual who was involved. Hopefully, they will be used in the quest to prevent disease and injury in the workplace.

To learn of the availability of the complete texts of Part 1 and Part 2, or to obtain additional copies of this or other Strategies, contact NIOSH Publications, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Telephone (513) 533-8287.

A Proposed National Strategy for the Prevention of Occupational Cancers

I. Occupational Cancers: Problems and Goals

This document develops a strategy for the prevention of occupationally induced cancer in workers. An organized and coordinated effort by the various levels of governments and the private sector will be required to implement this national prevention strategy.

Occupationally induced cancer usually occurs decades after the exposures that cause the disease process to begin. To date, observed associations between exposure and occupational cancer usually relate to tumors of a common type, such as lung cancer. However, the appearance of even a single case of a very rare form of cancer, such as angiosarcoma of the liver, may indicate an occupational etiologic factor. Sometimes specific cancers occur in such a high fraction of workers that recognition of an association with their job is inescapable. Cancer of the bone in radium dial painters is a good example. However, if only a modest increase in rate occurs, recognition of the association may be more difficult.

While present public health officials now ponder which occupational agents may be carcinogens and to what degree, it should be remembered that 200 years have passed since it was first recognized that chemical agents found in the workplace can cause occupational cancer. An astute clinician, Sir Percivall Pott, in 1775 first linked cancer of the scrotum among chimney sweeps to their occupational exposure. Like other observers lacking 20th century scientific knowledge and methods, Sir Percivall discovered this association using epidemiologic concepts such as the interactions of *agent*, *environment*, and *host*. No doubt, his confidence was bolstered by his observation of a specific *agent*, the soots and tars, and he probably wondered whether some attribute, such as the young age at which the boys (*hosts*) were exposed to the soots and tars, contributed to their unusual risk, and whether the *environment* in which the small boys worked could be altered to eliminate the continued contact of soots and tars with the scrotal skin. It was not until the 20th century that the particular mechanisms of carcinogenesis and the specific carcinogenic constituents of soot and tar were known. Once specific carcinogenic agents were found, researchers could identify the specific industrial processes producing the exposures and identify the workers at

risk. This provided an opportunity for prevention before clusters of disease occurred among the workers.

Healthy People. The Surgeon General's Report on Health Promotion and Disease Prevention, 1979, specifies three health actions for prevention: *health protection*, *health promotion*, and *health services*. These three may be specifically applied in the case of preventing occupational cancers.

Broadly, *health protection* encompasses activities directed at reducing exposure from the offending occupational carcinogen. Redesigning the job to eliminate exposure would be an example of *health protection*. Although *health promotion* has no commonly accepted definition, it connotes an organized program to help employees develop and improve behaviors conducive to good health. For example, cigarette smoking itself is hazardous, but combined with certain carcinogens found in occupational settings, such as asbestos or radon daughters, it can dramatically increase the risk of lung cancer and chronic lung disease.

An educational program aimed at smoking cessation and at warning of the combined hazards of smoking and exposures in the workplace is an example of *health promotion* applied specifically to the prevention of occupational cancers. The third method for intervention, and usually the least satisfactory in the prevention of occupational cancer, is through provision of personal *medical services*. Some cancers, particularly of the skin and bladder, if detected early, are more easily treatable and curable. It is through *health protection*, *health promotion*, and *health services* that the cancer-causing triad of *agent*, *environment*, and *host* can be disrupted and occupational cancer prevented.

II. Scope of the National Problem

Estimates of the fraction of cancers with occupational origin range widely. The limitations inherent in these estimates have been described (Cole and Merletti, "Chemical Agents and Occupational Cancer," Journal of Environmental Pathology and Toxicology, III: 399-417, 1980). Even the lowest estimate suggests that 17,000 cancer deaths are attributable each year to workplace exposures. These general estimates do not reflect the specific occupational association in distinct populations of workers exposed to carcinogens. It is not our intention to argue the precise fraction of cancers attributable to occupation or to debate whether this fraction is relatively large or small. Rather, we wish to point out that epidemiologic studies of specific occupational populations, at risk because they have exposure to carcinogens, have demonstrated rates of cancer substantially increased over the expected rate in the general population (Table 1.).

The most recent data collected in 1972 (NIOSH, 1978) indicate that 110,000 workers are potentially exposed to the 21 chemicals (2-acetylaminofluorene, acrylonitrile, 4-aminobiphenyl, inorganic arsenic, asbestos, benzidine, bis-chloromethylether, chloromethyl methyl ether, coke oven emissions, 1,2'-dibromo-3-chloropropane, 3,3'-dichlorobenzidine and its salts, 4-dimethylaminoazobenzene, ethyleneimine, ethylene oxide, alpha-naphthylamine, beta-naphthylamine, 4-nitrobiphenyl, N-nitroso-dimethylamine, beta-propiolactone, vinyl chloride, and coal tar) currently regulated as carcinogens by the Occupational Safety and Health Administration (OSHA). If those agents for which OSHA is currently developing standards (e.g., asbestos, benzene, formaldehyde, ethylene oxide, and ethylene dibromide) are added, the number exposed rises to an estimated 1.2 million workers. If one also adds those

agents not presently regulated by OSHA but recommended by the National Institute for Occupational Safety and Health (NIOSH) for control as carcinogens, the total number of workers estimated with potential for exposure increases to approximately 3 to 9 million. No comprehensive estimates exist for the size of the population with past exposure to occupational carcinogens. However, for asbestos alone, an estimated 27.5 million individuals have had past occupational exposure (Nicholson et al., "Occupational Exposure to Asbestos: Population at Risk and Projected Mortality 1980 — 2000," American Journal of Industrial Medicine III:259-311, 1982). Exposure is neither ubiquitous nor homogeneous but rather is confined to distinct populations with varying degrees of exposure to a diversity of carcinogens.

Table 1. Industrial Agents Associated with Cancer*

Agent	Target Organ	Relative Risk†
Asbestos	Lung, pleura, peritoneum, (mesothelioma)	1.5-12.0 100.0
2-Naphthylamine	Bladder	87.0
Benzidine	Bladder	14.0
Coke oven emissions	Lung, kidney	2.7
Benzene	Blood (leukemia)	2.5
Wood dust	Nasal cavity	500.0
Arsenic	Lung, skin	2.3-8.0
Chromium and chromates	Lung, nasal sinuses	4.0-20.0
Vinyl chloride	Angiosarcoma of the liver	Marked
Bis(chloromethyl) ether	Lung	100.0

* Abstracted from Schottenfeld and Haas: CA — A Cancer Journal for Clinicians 29: 144-68, (1979).

† Estimated relative risk for workers exposed to agent.

III. Potential for Prevention and Control

This strategy presents a continuum of techniques potentially effective for preventing occupational cancer. This continuum and its relationship to the triad of *agent*, *environment*, and *host* are shown in Table 2.

The strategy proposed for control of occupationally induced cancer consists of techniques implemented within the continuum of prevention. Each action in the continuum will be addressed, indicating what can be done now and what further knowledge is needed to better proceed in the future.

Table 2. The Continuum of Prevention as it Relates to the Triad of Agent, Environment, and Host

Preventive Practice	Agent	Environment	Host
Identification and evaluation of carcinogens	X		
Standard setting	X	X	X
Elimination and substitution	X		
Engineering controls		X	
Personal protective devices		X	X
Environmental monitoring	X	X	
Biologic monitoring	X		X
Medical screening			X
Health promotion			X
Therapeutic medical care and rehabilitation			X
Surveillance of disease			X
Surveillance of exposure	X	X	X
Compliance activities	X	X	X
Education of workers and managers		X	X
Use of free market forces for prevention	X	X	X

IV. The Continuum

A. Identification and Evaluation of Carcinogens

1. What Can Be Done Now

a. Establish a program to coordinate research in epidemiology and toxicology. Although too much coordination can stifle the creativity that leads to progress, improved coordination and communication are needed among all members of the occupational health and safety team (i.e., epidemiologists, toxicologists, industrial hygienists, safety engineers) and among the various professional disciplines. Groups outside government representing both industry and labor should be invited to participate in such coordinating committees. The example of The National Toxicology Program (NTP) within the federal sector illustrates the benefits of coordination. However, NTP does not coordinate or recommend *epidemiologic* research.

b. Increase support, including funding, for ongoing research to improve methods in epidemiology, toxicology, industrial hygiene, and screening.

2. What Knowledge Do We Need

   a. An inventory of agents that warrant toxicologic and epidemiologic study should be established through an expert committee consisting of the involved government agencies and the nongovernmental sector, including industry management, labor, and academia. Setting priorities and updating the list of agents should be an integral part of the committee's responsibility. Governmental agencies should be required to consider these data in establishing research priorities and setting their regulatory agendas.

   b. Increased understanding is needed of the development, evaluation, and standardization of short-term toxicologic studies, such as cellular and subcellular tests, to delineate their usefulness for decision makers charged with the prevention of occupationally induced cancer. Epidemiologic research often requires substantially more time to complete than experimental studies in animals, while research at a cellular or even subcellular level can be completed more quickly than the other two and may prove less expensive. Unfortunately, results from cellular and subcellular studies are more vulnerable to question because of their uncertain prognostic value for workers.

B. Setting Standards

Several systems exist for setting or recommending occupational standards to prevent exposure to carcinogens. In the workplace, the most familiar is that derived from the Occupational Safety and Health Act, which mandates that NIOSH develop recommendations for OSHA to use in promulgating suitable occupational health and safety standards. Difficulties of this process include the time involved in regulating carcinogens on an agent-by-agent basis; this led OSHA to promulgate a Carcinogen Policy. Standards can also be established for the workplace by other federal agencies, such as the Mine Safety and Health Administration (MSHA) and by state governments, companies, and insurance carriers. Recommendations for standards are also made by voluntary groups, such as the American Conference of Governmental Industrial Hygienists (ACGIH), and the American Industrial Hygiene Association (AIHA).

1. What Can Be Done Now

   a. Clear the backlog of unregulated carcinogens used in general industry by full use of the carcinogen policy that OSHA promulgated in 1981.

   b. Encourage NIOSH, ACGIH, AIHA, NTP, the International Agency for Research on Cancer (IARC), and other groups to continue to identify carcinogens found in the workplace and to promote recognition, voluntary compliance with recommended standards, and the setting of new standards.

   c. Provide technical assistance through NIOSH to states, companies, labor organizations, government agencies, and others in efforts to set standards.

   d. Encourage voluntary organizations to continue disseminating information on carcinogens to all potentially exposed groups.

e. Encourage efforts to provide information about carcinogenic hazards to workers. One such communication mechanism could be through implementing a broad-based hazard communication standard.

2. What Knowledge Do We Need

Gaps in information used to set priorities for epidemiologic and toxicologic studies should be identified. Ongoing assessments should be conducted of these gaps in information, and the information obtained should be used to influence the selection of toxicologic, epidemiologic, and other research studies needed to support preventive actions.

C. Elimination and Substitution

The most effective way to eliminate exposure to a carcinogen is to eliminate the carcinogen from the workplace. In some cases, the risks of using an agent exceed the benefits, and no valid argument exists for keeping the carcinogen in the workplace. In other instances, interventions less effective than eliminating the agent must be relied on to protect workers.

1. What Can Be Done Now

Increase the efforts of NIOSH, OSHA, MSHA, and other organizations in working with industry, labor, and consumers to obtain information on the toxicity of substitutes that are potentially usable and less hazardous. Lack of toxicity information is sometimes an impediment to eliminating a carcinogen or effectively substituting for carcinogens now in use. Lists of potential carcinogens, substitutes, and replacements should be developed and broadly disseminated.

2. What Knowledge Do We Need

Improved understanding is needed of the potential toxicity and carcinogenicity of materials intended for substitution. When appropriate, recommendations should be made for testing before use.

D. Control Technology

Control technology consists of *engineering controls* that enclose a system or provide ventilation, *administrative controls* that protect against intentional or inadvertent exposure, and *work practices* that minimize worker exposure. Engineering controls are the most preferable, because they are perceived as less likely to fail than personal protective devices or work practices. They also permit the capture and reuse of products that would otherwise be lost to the ambient environment.

1. What Can Be Done Now

a. Establish a national clearinghouse for information on effective engineering controls and promote the distribution of such information. Government agencies, industry, labor, and academia should work jointly in this effort.

b. Encourage studies to evaluate the effectiveness of control technologies now used in industry.

2. What Knowledge Do We Need

a. Examples of effective engineering controls should be identified for specific agents as they are slated for standard setting. A concomitant search for such examples should be made and the information made available through the clearinghouse.

b. Effective means should be sought to introduce control technology into small businesses that often have no inhouse industrial hygiene services.

E. Personal Protective Devices

When use of a carcinogen in the workplace is essential, and when engineering controls are unavailable or inadequate to ensure protection of the workers, personal protective devices, such as respirators and protective clothing, have a role. The appropriate matching of protective device to hazard is critical because the carcinogens may enter the body by many different routes, including absorption through the skin, inhalation, and ingestion. In addition, personal protective devices are often very specific to the nature of the agent. For example, a glove may be impervious to some solvents but not to others. This requires considerable attention and testing to ensure efficacy. Paradoxically, if a solvent leaks into an impervious glove, the glove may hold the solvent and actually increase rather than minimize absorption. Personal protective devices may even introduce hazards into the workplace, for example, by interfering with vision and dexterity. The effective use of personal protective devices depends on a series of personal and physical assessments of the workers, including their comfort, their perceived value of the device in protecting health, and their physical ability. Personal protective devices must be safe, effective, comfortable, acceptable, and perceived by the worker as valuable if they are to contribute to prevention.

1. What Can Be Done Now

a. Establish a clearinghouse to disseminate state-of-the-art information on personal protective devices, including information on their failures.

b. Continue certifying respirators at NIOSH and alert users to possible failures or defects.

c. Establish medical guidelines to determine which workers are able and which are unable to use personal protective devices effectively.

2. What Knowledge Do We Need

Information based on field testing of personal protective devices is needed to assure their ability to perform in actual work situations; carefully conducted laboratory research on these devices is also important.

F. Environmental Monitoring

Essentially, the role of environmental monitoring is to measure the amount of a carcinogen found in the workplace, to assess the adequacy of engineering controls, and to determine the need for personal protective devices. The complexity of chemical analyses used in environmental monitoring can be a limiting factor in the control of occupational carcinogens.

1. What Can Be Done Now

a. Encourage NIOSH, OSHA, MSHA, industry, and others to press for the development and dissemination of better and more precise analytic methods for monitoring known and suspected occupational carcinogens.

b. Support the development of laboratory performance standards through NIOSH and coordinate the testing of laboratories to ensure their accuracy when performing analyses of carcinogens.

c. Develop and validate strategies for environmental monitoring of carcinogens for field and laboratory use.

2. What Knowledge Do We Need

a. A plan should be developed to coordinate field validation of analytic methods for carcinogens to ensure that they are as accurate in the field as in the laboratory. NIOSH could provide a lead role in this effort.

b. A surveillance system should be established to collect, evaluate, and disseminate the results of environmental monitoring.

G. Biologic Monitoring

Two types of biologic monitoring can be done. First, tests are available to measure inherent biologic characteristics of individuals, such as genetic phenotyping for certain enzymes. Second, tests can assess the absorption of specific carcinogens or their metabolites. Little information is available, however, on the value of these tests in preventing disease or on the validity of tests performed in laboratories.

1. What Can Be Done Now

a. Assess the efficacy of biologic monitoring methods under field conditions, starting with test systems that have been validated in laboratory experiments.

b. Conduct surveillance of the test results of biologic monitoring for carcinogens or their metabolites in order to identify the worksites where there is exposure to carcinogens.

2. What Knowledge Do We Need

a. Understanding is needed of the validity of tests that determine enzymatic constitution and of their use in predicting carcinogenic risk. Validation of these tests will determine whether individuals with unusual enzymatic constitutions actually have higher risks of cancer. This will help in developing effective preventive measures and protecting workers against discrimination by use of the tests.

b. The proficiency of commercial laboratories that perform biologic testing should be ascertained. Currently no laboratory proficiency programs exist for biologic testing, except the biologic testing for some heavy metals.

c. Research should be initiated into new biologic monitoring methods.

d. Research is needed to clarify the relationship between monitoring results and disease endpoints.

H. Medical Screening

Cases of occupational cancer continue to occur because of failures in the continuum to prevent them. If these diseases could be detected in the early phase, patients could be treated more successfully and would serve as sentinels that coworkers are at risk.

1. What Can Be Done Now

a. Establish a series of expert consensus workshops to evaluate the efficacy of medical screening techniques, such as urinary and sputum cytology.

b. Disseminate state-of-the-art information on medical screening.

c. Review NIOSH recommendations and OSHA and MSHA regulations on medical screening periodically to ensure that they are consistent with state-of-the-art scientific knowledge.

2. What Knowledge Do We Need

a. The effectiveness of medical screening techniques for the detection of cancer should be determined.

b. The effectiveness of subsequent therapy in minimizing and treating occupational cancer should be determined.

c. More effective methods are needed to identify populations with past exposure to carcinogens so that they can be targeted for effective medical intervention, if available.

I. Health Promotion

Health promotion is generally conceived as an organized program designed to help participants develop and improve their own health maintenance behavior. Only lifestyle factors are considered in this strategy because attempts to help workers reduce their own exposure to occupational hazards are considered health protection. Clearly, cancer can be reduced through health promotion, for example through smoking cessation. Workers exposed to carcinogens may have even greater benefits from smoking cessation than the general population because some carcinogens, such as asbestos, act synergistically with cigarette smoke to increase the worker's risk of cancer more than either agent acting alone. Health promotion should not be considered a substitute for health protection, but an adjunct to the overall prevention strategy.

1. What Can Be Done Now

a. Include workers and workforces with the other populations targeted for health promotion activities. The American Occupational Medical Association (AOMA), the American Association of Occupational Health Nurses (AAOHN), the American Industrial Hygiene Association (AIHA), and other professional associations could take the lead in this effort.

b. Support projects that will sensitize the health care establishment to the specialized needs of certain occupational populations.

2. What Knowledge Do We Need

A clear delineation of the interaction between occupational exposures and personal health behaviors is needed to identify those areas where health promotion programs can be most effective and to determine which occupational groups would most benefit.

J. Therapeutic Health Care and Rehabilitation

A decade ago, few clinical experts specialized in the treatment of cancer. Physicians, nurses, or other health care delivery personnel received little training in the prevention of cancer or in occupational medicine. Since then the field of clinical oncology has burgeoned, but the number of hours in the general medical training program devoted to occupational medicine has not expanded comparably. Since many workers are employed in small companies outside the purview of regulation, their medical care is delivered by physicians who are not specially trained in occupational medicine.

Epidemiologic research in the last 25 years has identified numerous populations of workers at increased risk of occupational cancer. Some of these workers could benefit from medical screening, programs for risk reduction, or early treatment. Minorities, who often have the least adequate medical care, should receive prominent attention.

1. What Can Be Done Now

a. Increase efforts by NIOSH with medical schools, professional associations, and schools of public health to design instructional materials that establish training programs in the prevention of occupational cancer.

b. Increase collaboration of the American Occupational Medicine Association and other professional organizations, such as the American College of Physicians, with NIOSH in developing educational materials for primary care physicians.

c. Offer certificates for earned educational credits so that labor and industry can differentiate physicians with some training and understanding of occupational diseases from those without such training.

d. Establish educational programs and credits of achievement for nurses, in collaboration with the American Association of Occupational Health Nursing, as noted above for physicians.

e. Increase support to the National Cancer Institute (NCI), which has been instrumental in establishing a network of occupational medicine clinics with strong interests in occupational cancer.

f. Place experienced occupational health personnel in state and local agencies to encourage interest in the prevention of occupational cancer.

2. What Knowledge Do We Need

a. Additional information should be gathered from trials of medical interventions. These trials are necessary to determine whether therapy of specific occupational cancers detected early is effective in prolonging life and maintaining its quality.

b. Understanding should be sought of the most effective ways to provide preventive medical services for small businesses and those not covered by regulation.

c. The adequacy of early detection, therapy, and risk reduction techniques should be assessed through careful research.

d. Information is needed to identify populations with past exposures to carcinogens or those known to be at increased risk of cancer. Programs should be initiated for these populations to ensure timely application of diagnostic and therapeutic services.

K. Surveillance of Disease

Occupationally induced cancer is characterized in part by the long interval—often decades—between first exposure and the expression of disease. Thus, surveillance of the disease state will do little to identify worksites with important current exposures. Surveillance of occupational cancer may, however, be effective in detecting new associations between agent, environment, and host. If medical screening and therapeutic interventions prove effective, cases of cancer reported through a surveillance scheme may become sentinel events that identify populations with past exposures who may yet benefit from medical intervention.

1. What Can Be Done Now

a. Evaluate surveillance schemes to determine which are the most effective in identifying populations that can be helped. This assumes that intervention techniques are available and valuable.

b. Identify and include sentinel diseases other than cancer in surveillance schemes. Certain acute illnesses, such as chrome dermatitis, may serve as sentinels of important current exposures to known carcinogens.

c. Place experienced personnel with a knowledge of surveillance in local and state agencies to encourage interest in cancer detection, reporting, and prevention.

2. What Knowledge Do We Need

Better understanding is needed of record-linkage systems and their availability. In the last few years vital statistics data have become available that facilitate the work of epidemiologists (e.g., National Death Index). Other records worth exploring include those collected by the Internal Revenue Service, the Social Security Administration, Workers' Compensation systems, and insurance carriers.

Surveillance of Exposure

Exposure to carcinogens today may lead to cancer 20, 40, or more years hence. Unfortunately, no systematic survey information is now available that gives the extent and level of exposure to suspected human carcinogens or even to the known carcinogens. Such information would be useful for directing societal resources to workplaces with the greatest potential for problems.

1. What Can Be Done Now

Explore data collected in OSHA and MSHA compliance programs to evaluate their usefulness for exposure surveillance. This information may be useful to estimate the extent and level of exposure to regulated and unregulated carcinogens.

2. What Knowledge Do We Need

Systems should be developed to provide national surveillance of occupational exposure to regulated and suspected carcinogens.

M. Compliance Activities

OSHA conducts two major types of inspections—some in response to requests and others targeted to "high risk" industries. The formula for targeted inspections provides that industries with the highest infraction rates in past years be selected for inspection.

1. What Can Be Done Now

a. Design and evaluate the efficacy of a national system that would target compliance activities to inspect plants using regulated or suspected carcinogens. Because the effects of exposure will not be manifested for 20 to 40 years, inspections are needed to determine whether exposures to carcinogens are occurring.

b. Determine through an evaluation whether OSHA's current inspection activities are sufficient to ensure coverage of all potentially exposed workers.

N. Education of Workers and Managers

Action to control occupational cancer must come not only from management, professionals, and government, but also—and perhaps primarily—from the interactions of managers and workers, acting in their own self-interests to prevent disease. Education is essential for effective interaction.

1. What Can Be Done Now

a. Increase the commitment of NIOSH, OSHA, MSHA, NCI, the schools of public health, insurance carriers, and labor to strengthen their educational programs directed at workers, worker representatives, and employers and to include information on the prevention of occupational cancer.

b. Encourage efforts to provide more information to workers. Implementing a broad hazard communication standard could be an effective part of this program. An evaluation of the effect this communication will have on the behavior of workers should be an integral part of the standard.

c. Promote worker awareness of occupational cancer hazards and an adherence to the safeguards designed to reduce such risks. This can be done by formulating optimal communication strategies, including public awareness programs.

d. Establish the value of behavioral approaches and job-design factors in furthering efforts to control cancer in the workplace.

O. Use of Free Market Forces for Prevention

This broad category includes a diverse array of activities unified by the concept that industry and labor operate within an economy as well as a society. Economic forces can be harnessed to help prevent occupational cancer.

1. What Can Be Done Now

Encourage measures to ensure compensation for victims of occupationally induced cancer and allow alternative approaches for reparations. In practice, victims of occupational cancer generally do not receive workers' compensation for several reasons, including the long interval between exposure and disease and the difficulty in establishing a causal relationship between exposure and disease for a particular worker.

2. What Knowledge Do We Need

Understanding is needed to help facilitate collaboration between the occupational health community and the insurance industry in designing economic incentives to maintain a healthful workplace.

V. Summary

More than two centuries have elapsed since an agent found in the workplace was first identified as the cause of cancer in workers. A strategy has been outlined here to better prevent occupationally induced cancer. In the broadest sense, this strategy is an attempt to disrupt the triad of *agent*, *environment*, and *host*. These elements work together to produce occupational cancer, and the different combinations of *agent*, *environment*, and *host* needed to produce the disease depend on the actions of the specific carcinogens. This prevention strategy points the way to a disruption of the triad through *health protection*, *health promotion*, and *health services*. *Health protection* appears to have the most potential for effectively and efficiently preventing occupational cancer, and *health promotion* and *personal medical services* are important adjuncts in this strategy.

Contributors

NIOSH WORKING GROUP MEMBERS

William Halperin, M.D., Chair

Paul Caplan

Todd Frazier, Ph.D.

Francis Green, M.D.

David H. Groth, M.D.

James H. Jones

Kathryn Mahaffey, Ph.D.

Robert Mullan, M.D.

Richard W. Niemeier, Ph.D.

Paul Schulte, Ph.D.

SYMPOSIUM PANELISTS

Richard A. Lemen, M.S.P.H., Chair
National Institute for Occupational Safety and Health

Morton Corn, Ph.D.
Johns Hopkins University

William D. DeWys, M.D.
National Cancer Institute

Ernest M. Dixon, M.D.
American Academy of Occupational Medicine

John F. Finklea, M.D.
University of Alabama

Melvin W. First, Sc.D.
Harvard School of Public Health

K. D. McMurrain, Jr., M.D.
Procter and Gamble Company

Phillip L. Polakoff, M.D., M.P.H.
Integrated Health Management Associates

David Schottenfeld, M.D.
Memorial Sloan Kettering Cancer Center

Margaret Seminario, M.S.
Occupational Safety, Health, and Social Security, AFL-CIO

Jesse L. Steinfeld, M.D.
Medical College of Georgia